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Did Just-In-Time Management Effectively Decrease Inventory Ratios in Belgium?*

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ABSTRACT

It is almost unquestionably accepted by most observers that inventory ratios decreased over time. There are so many Enterprise Resource Planning systems implemented and so many just-in-time ideas successfully introduced in companies that we almost automatically conclude that inventories went down. However, as will be shown in this study, this conclusion is somewhat hasty. Since most inventory reduction and just-in-time principles were introduced somewhere in the early 1980s, we examine whether inventory ratios effectively decreased from this era onwards. We find that finished product inventory ratios did actually not decrease, whereas work-in-process and raw materials inventory ratios did go down in only half of the industrial sectors. This is the main conclusion from our econometric study performed on industry data (15 industrial sectors) during the period 1979-2000. In this paper we focus on the econometric model of our study, we interpret the results and we conclude with a number of managerial insights.

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I. INTRODUCTION

There is ample anecdotic evidence that inventories went down in the period 1979-2000. In the beginning and mid eighties we experienced the just-in-time revolution, characterized by a strategy to ban inventories, the root cause of all evil. Just-in-time (JIT) can be defined as an integrated set of activities designed to achieve high-volume production using minimal inventories and to eliminate waste in production effort (Chase, Jacobs and Aquilano (2004) and Chary, Herroelen and Lambrecht (1991)). Over the same period we observed that numerous companies introduced Manufacturing Resources Planning (MRP) and more recently, Enterprise Resources Planning (ERP) systems were introduced in many large corporations. The focus on supply chain collaboration is now well accepted and many companies managed to implement lead-time reduction programs. The focus on quality needs no further explanation. High inventory holdings are commonly identified as poor management. All of these operational improvement tools, undoubtedly, must have resulted in less inventories and improved efficiencies. Many handbooks and seminar gurus will paint this rosy picture and illustrate their gospel with appealing examples and successful stories. Moreover, there is a well known theoretical argument why inventory ratios (e.g. *Total Inventory / Cost of Goods Sold*) must decrease over time: the economic order quantity (EOQ) tells us that inventories change proportionally to the square root of sales. If sales increase by 10%, then the average inventory will increase only by a few percentages, and as a consequence the inventory ratio will decrease. However, as we will argue later on in this text, there are also factors forcing inventory ratios to increase.

In this paper we ask about basic patterns observed in inventory holdings. Did inventory ratios actually fall? Was there an equal effect on raw materials, work-in-process and finished goods? In section II we review the literature and summarize the major findings. In section III we present our econometric model and discuss the data used. In section IV we interpret the results and we focus on a number of important managerial insights. In section V we conclude.

II. LITERATURE REVIEW

There are a lot of papers dealing with the question whether inventories went down, especially focusing on the before/after JIT introduction

effect. Balakrishnan, Linsmeier and Venkatachalam (1996) conclude that JIT had no effect on reported return on assets. Huson and Nanda (1995), however, conclude that JIT adopters decreased inventories. Sakakibara, Flynn, Schroeder and Morris (1997) found mixed evidence. The three studies mentioned are all based on relatively small samples of firms, surveys of managers or questionnaire studies. So, caution is needed and the results are hard to generalize.

It is possible to study the problem at the industry level or at the firm level. Our study, reported in this paper, is on the industry level; consequently we use aggregate industry level data published in the national statistics. The best known study on the industry level was published by Rajagopalan and Malhotra (2001) focusing on the U.S. manufacturing sector. They used the two-digit SIC code comprising 20 manufacturing industry sectors during the period 1961 to 1994. They found that raw material and work-in-process inventories did decrease in a majority of the two-digit industry sectors. Finished goods inventories decreased in some industry sectors, increased in a few others but did not show a significant trend in more than half of the sectors. The analysis provides in other words a somewhat mixed picture about the results of the U.S. manufacturing inventory-reduction efforts. In this paper we repeat the same study for the Belgian industrial sector. Rajagopalan and Malhotra (2001) also study whether greater improvement was seen in the post-1980 period as compared with the pre-1980 period. 1980 is seen as a momentum for inventory reduction due to the introduction of JIT. Amazingly enough, total manufacturing inventory ratios did not improve at a higher rate during the post-1980 period as compared with the pre-1980 period in any of the inventory categories. For certain industrial sectors however, we do observe a greater improvement. An analogue study was done by Ginter and La Londe (2001). They came to the conclusion that the finished goods inventory ratio (finished goods inventories over cost of goods sold) increased in seven of the fourteen industries studied (namely apparel, chemicals, electrical/medical equipment, food products, furniture/home furnishings, medical products and other consumer packaged goods). They observed decreased inventory levels for raw materials and work-in-process in a large majority of industries.

Finally we would like to review an excellent study by Chen, Frank and Wu (2003) based on firm level data. They analysed balance sheet data from 6077 manufacturing firms (USA) over a twenty-year period

(1981-2000). A key metric the authors use is inventory days. It measures the length of time that goods are held.

Inventory days, $ID_{i,t}$ of firm i in year t is:

$$ID_{i,t} = \frac{Inventory_{i,t} \times 365 \text{ days}}{(Cost \text{ of Goods Sold})_{i,t}}$$

Replacing $Inventory_{i,t}$ (firm i 's inventory in year t) with raw material inventory, work-in-process inventory or finished goods inventory in the above equation gives measures of how long each of these components of inventory are being held.

The main conclusion from their analysis is that inventories did fall (we give the overall industry numbers, not differentiated by sector). In 1981 the median of inventory days was about 98 days (3,72 inventory turns per year). By 2000 this had fallen to a median of 80 days (4,56 turns per year). Raw material accounted for 35 days (median) in 1981 and dropped to 27 days. Work-in-process came from 23 days to 9 days. Finished goods dropped from 32 days to 30 days (not statistically significant). We again can conclude that finished goods inventories seem to be hard to manage. A major improvement can be found in work-in-process. We observe minor improvements in the management of raw materials. A detailed analysis of individual industries will give a more differentiated picture.

Another interesting metric is $AID_{i,t}$ denoting abnormal inventory days of firm i in year t . It measures the extent to which a firm's inventory deviates from the industry norm. It is defined as:

$$AID_{i,t} = \frac{ID_{i,t} - \text{mean(inventory days of firm } i \text{'s industry in year } t \text{)}}{\text{standard deviation(inventory days of firm } i \text{'s industry in year } t \text{)}}$$

If $AID_{i,t} > 0$ then in year t , firm i is holding inventory longer than other firms in the same industry. If $AID_{i,t} < 0$ then the opposite is true. Chen, Frank and Wu (2003) relate the above metric to the financial performance of the firm. If firms reduce inventories, can we then conclude that the financial position will improve? The authors conclude after extensive analysis that inventory does not seem to matter much for the market-to-book ratio. However, firms with abnormally high inventories do have poor stock returns over time. More surprising,

firms with the lowest levels of inventory did not have good performance either. This may mean that the super lean companies operate in commodity type of businesses with low profit margins. This argument was raised by Oliver and Hunter (1994) who argue that lean businesses operate in sectors where the competition is stiffer and hence profit margins are lower.

III. EVOLUTION OF INVENTORY RATIOS IN THE BELGIAN MANUFACTURING SECTOR

In this section we report on the Rajagopalan and Malhotra methodology applied to the Belgian manufacturing sector. We chose to use sector level data simply because of data availability. The data were obtained from the National Bank of Belgium and we therefore adopted their definition of industrial sectors. This definition is based on the NACE-70 classification until 1995 and afterwards on the NACE-BEL classification. This change does not affect the results for the sectors we analysed; it only means that we had to be careful in collecting the data. We defined three main sectors “non-energetic minerals & chemicals”, “metal processing & optics” and “other manufacturing sectors”. These main sectors can be further split up in sub-sectors, which can be analysed separately. Non-energetic minerals & chemicals are split up in iron & steel, non-ferro metals, non-metallic minerals and chemicals. For the metal processing & optics sector, we only consider electronics & ICT. The “other manufacturing sectors” consist of food & tobacco, textile, apparel, wood & furniture, paper & printing and rubber & plastics. Finally, we also analyse the total manufacturing sector as a whole. This results in 15 sectors, including different levels of aggregation.

In order to analyse the evolution of the inventory ratios over time (raw materials, work-in-process, finished goods and total inventory), we estimate the following regression equation for each inventory ratio and for each sector:

$$(Inventory\ ratio)_t = \beta_0 + \beta_1 \times time + \beta_2 \times (output\ growth)_t$$

or

$$y_t = \beta_0 + \beta_1 \times t + \beta_2 \times og_t + \varepsilon_t$$

A common finding in time series regressions is that the residuals ε_t are correlated with their own lagged values, which is known as auto-correlation or serial correlation. An appropriate method for removing serial correlation is to create an autoregressive moving average model in the disturbances (see Hanke and Reitsch (1998) and Verbeek (2000)). In our case, a first order autoregressive term suffices in the majority of the regression models and in some cases an additional moving average term is required to have white noise residuals.

As dependent variable we use inventory ratios (see Table 1). It is clear that we cannot use absolute values of inventory in euro; instead we have to use relative measures because this corrects for inflation and sector size.

The raw material inventory ratio is quite obvious (changes in prices of raw materials will not affect the analysis because we use ratios). In the work-in-process inventory ratio we use the coefficient of 0,5 for the value added. Although this coefficient is commonly used, it is quite arbitrary, but this poses no problem since we use the same factor in all years and we are more interested in comparisons over time within an industry rather than across sectors. In the finished goods inventory ratio we use value added + material cost instead of the more classical cost of goods sold. Value added is defined as value of shipments minus material cost. The denominator of the finished goods inventory ratio is in other words equal to value of shipments. This way we take into account that it may be justified to hold higher

TABLE 1
Inventory ratios

Inventory Type	Ratio
Raw Materials	$\frac{\text{inventory raw materials}}{\text{material cost}}$
Work In Process	$\frac{\text{inventory work in process}}{\text{material cost} + 0,5 \times \text{value added}}$
Finished Goods	$\frac{\text{inventory finished goods}}{\text{material cost} + \text{value added}}$

inventories for goods with higher profit contributions. We also introduced a fourth ratio, which refers to the total inventory position. The total inventory ratio equals:

$$\frac{\text{inventory raw materials, work in process and finished goods}}{\text{material cost + value added}}$$

As independent variables we use time and output growth (representing the growth of the sector). The use of time is obvious since we are interested in the rate of change in inventory ratios over time. The second independent variable (output growth) is included to correct for the impact of economic swings. This variable is measured as the percentage change in the value of shipments (output) in a sector from year $(t-1)$ to t . When output growth is high, companies will experience high demands, depleting the inventory and consequently the inventory ratio will be lower. We expect that inventory ratios should be negatively correlated with growth rates. There may be other variables that have an impact on the inventory ratios, such as export activity, level of outsourcing, product variety, etc. However, since our main objective is to study whether the time trend is a significant factor in the inventory evolution, we decided not to include these additional variables in our regression model.

The results of the regression analysis for raw materials, work-in-process, finished goods and total inventory for Belgian manufacturing sectors (the sector names are followed by the National Bank codes) are given in Table 2. In case the evolution is statistically significant, it is followed by the significance level at which the null hypothesis of no significant evolution ($H_0: \beta_1 = 0$) is rejected.

In Figures 1 through 4 we graphically represent the evolution of inventory ratios for four sectors (iron & steel, chemicals, food & tobacco and textile). We refer to Lambrechts (2003) for the complete data set.

In Figure 5 we plot the total inventory ratio for the six sectors showing a significant (throughout the text we interpret at 0,1 level, unless mentioned otherwise) decrease in total inventory holdings: other manufacturing sectors, food & tobacco, textile, wood & furniture, paper & printing and rubber & plastics. We observe a positive trend for the apparel sector and for the remaining sectors no significant trend was detected.

TABLE 2
Regression results for raw materials, work in process, finished goods and total inventory for Belgian manufacturing sectors

	Raw materials		work in process		finished goods		total inventory	
	<i>time</i>	<i>output growth</i>	<i>time</i>	<i>output growth</i>	<i>time</i>	<i>output growth</i>	<i>time</i>	<i>output growth</i>
TOTAL MANUFACTURING SECTOR (PU290)	−0,0011	−0,0125	0,0014	−0,0180	−0,0001	−0,016****	0,0025	−0,0391*
non-energetic minerals & chemicals (PU2311)	−0,0012*	−0,0353*	0,0002	−0,0064	0,0000	−0,025**	−0,0003	−0,0421**
iron & steel (PU2303)	0,0012	−0,099***	0,0040**	0,0290	0,0000	−0,0375**	0,0093	−0,101***
non-ferro metals (PU2304)	0,0012	−0,0038	−0,0065	−0,0557	0,0017***	−0,0327	−0,0032	−0,071***
non-metallic minerals (PU2302)	−0,0053**	−0,0395*	−0,001***	−0,0009	−0,0008	−0,0024	−0,0029	−0,059****
chemicals (PU2312)	−0,0009*	−0,0354**	0,0000	−0,0104**	−0,0008**	−0,0138	−0,0012	−0,039***

metal processing & optics (PU2511)	0,0023	−0,0031	0,0022	−0,0735	−0,0001	−0,0087	0,0050	−0,0712*
electronics & ICT (PU2611)	0,0000	0,0516	−0,0011	0,0229	−0,001***	0,0091	0,0016	0,0550
other manufacturing sectors (PU2850)	−0,002****	0,0135	−0,001****	0,0033	0,0000	−0,0101	−0,002****	0,0058
food & tobacco (PU270)	−0,001****	0,0217*	−0,001****	−0,0004	0,001****	−0,0086	−0,0006**	0,0022
textile (PU2801)	−0,003****	0,0012	−0,0004	−0,0005	−0,0007**	−0,015****	−0,003****	−0,0045
apparel (PU2802)	0,0044	0,0056	0,0005	−0,0055	0,0000	−0,0023	0,0017***	−0,0053
wood & furniture (PU2803)	−0,0009	−0,021***	−0,001****	−0,015***	0,0004	−0,0162*	−0,0010*	−0,0270
paper & printing (PU2811)	−0,003****	0,0442**	−0,001****	0,0048	−0,0001	−0,0121	−0,002****	0,0372*
rubber & plastics (PU2301)	−0,002****	−0,0271**	−0,001****	−0,0001	−0,001***	−0,0114	−0,002****	−0,0151

* 0,1 level, ** 0,05 level, *** 0,01 level, **** 0,001 level

FIGURE 1
Evolution of inventory ratios for the iron & steel sector

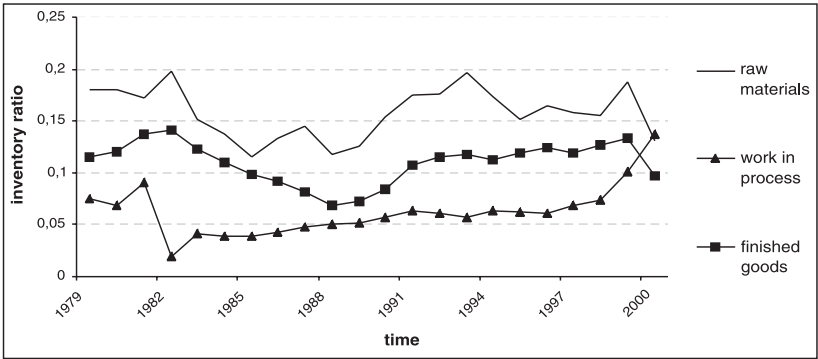


FIGURE 2
Evolution of inventory ratios for the chemicals sector

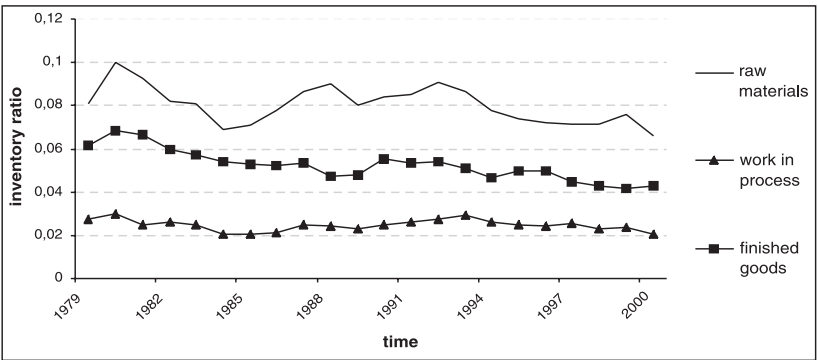


FIGURE 3
Evolution of inventory ratios for the food & tobacco sector

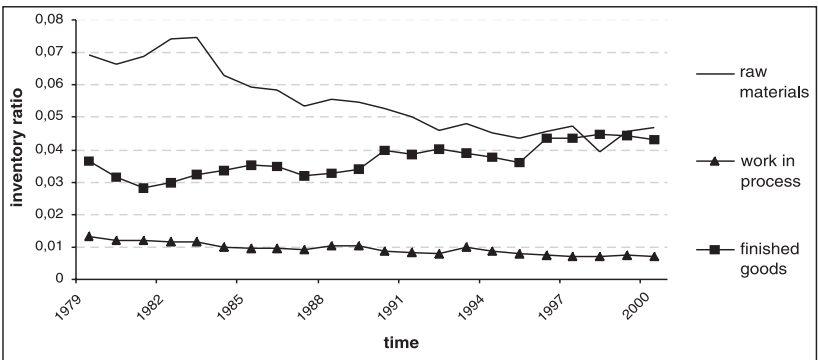


FIGURE 4
Evolution of inventory ratios for the textile sector

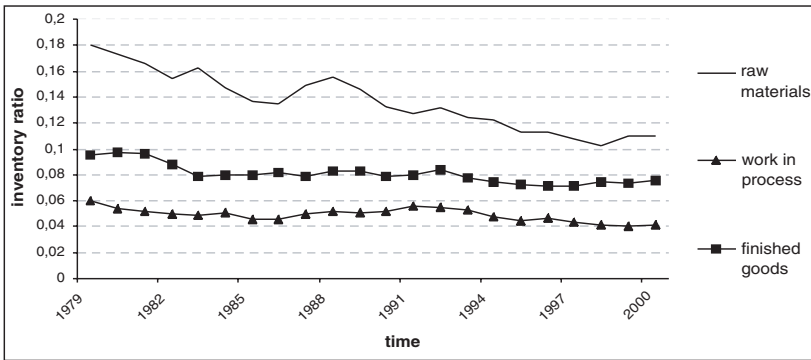
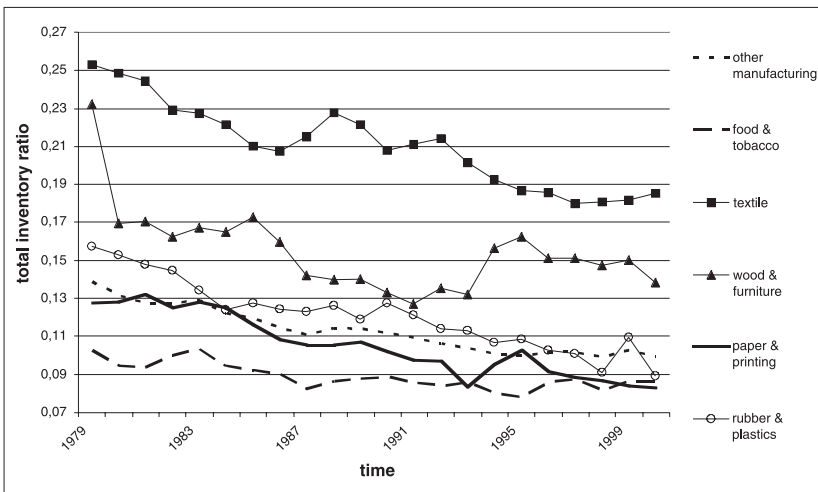


FIGURE 5
Evolution of total inventory ratios for 6 manufacturing sectors



Let's further interpret the results. If we look at the total manufacturing industry, we did not observe a significant trend for any of the inventory ratios. These results are not in line with the Rajagopalan and Malhotra (2001) study (who did observe a decrease in raw materials and work-in-process).

The raw material inventory ratio significantly decreases in eight sectors and we observe a decrease in work-in-process inventories in

six sectors. As expected, the finished goods segment is not performing very well. Only four sub-sectors (chemicals, textile, electronics & ICT and rubber & plastics) show a significant decrease. Overall we can conclude that we observe the same patterns as in Rajagopalan and Malhotra (2001), but the number of Belgian manufacturing sectors in the category “statistically significant decrease” is smaller compared to the U.S.A. This could be due to the higher export orientation of the Belgian economy, a factor causing inventories to increase.

At first sight, this seems to be a disappointing performance. Indeed, there is still plenty of room for improvement, but we must interpret the results with care. This will be done in the next section.

IV. INTERPRETATION OF THE RESULTS AND A NUMBER OF MANAGERIAL INSIGHTS

In this section we will speculate on potential causes of the mixed picture of the state of inventory reduction we observed both in the U.S. and in the Belgian study. In doing this, we will often refer to phenomena on the firm level. If we summarize the effect of these phenomena per sector (as we did in our sectoral analysis) there will obviously exist some form of aggregation bias. Good and bad performing firms partially cancel out. Therefore, it might well be that our findings on a sector level are even more explicit on the firm level.

Let's start with a general remark. MRP and ERP systems are meant to lower the inventory investments, to free cash for other uses, etc. According to our experience, we believe that managers are somewhat overoptimistic concerning the potential savings. Reducing inventories is much more than installing a piece of software; the whole incentive system has to change as well. A number of operational metrics, used to measure performance, do not go in the same direction. Obtaining high utilization rates on equipment and people is still a dominating performance criterion, no need to say that inventory reduction requires in many cases just the opposite. Revenue enhancing strategies require higher availability of products, more product variety and fast response, which may cause inventories to increase. Cost reduction programs on the other hand will focus on high utilizations (which means more waiting) and outsourcing to low wage regions, resulting in inventory increases. A good inventory strategy has to balance both views. Inventory holdings are not always bad, inventories do have a return as well.

We have to develop a profit view of inventory management and not just a cost view. We also observe that “crude inventory” policies are used in many companies, while there are so many powerful tools to better determine e.g. lot sizes, that unfortunately did not find their way to implementation.

We either observe a statistically significant increase or no trend in finished goods inventories in a number of sectors (see e.g. the food industry). Schonberger (2001) analysed 585 companies in 18 countries and found among other things that highly finished goods inventory intensive businesses turn out to be among the worst performing sectors as measured by trends in inventory turnover. How come we observe increased finished goods inventories?

Let’s analyse the finished goods inventory ratio (*Finished Goods Inventory / Value of Shipments*) for the Belgian wholesaling and retailing sector. The results are given in Table 3. We observe a significant decrease in finished goods inventories for retailing and no significant trend in the wholesale sector (we analyse the period 1978-2000). One possible interpretation is that retailers managed to push the inventory upstream to wholesalers and manufacturers. The finished goods inventory ratio for retailing was 11,39% in 1978 and went down to 9,62%; wholesalers on the other hand have an average ratio of only 8,17%, which is slightly lower, probably due to less variety in the assortment.

More customer service means more finished goods inventories, especially in an environment characterized by a tremendous increase in product variety. In many industries, we are facing an explosive growth in the number of new product introductions. Companies want to avoid the commodity trap and therefore explore new markets and increase product variety. According to theory this results in higher inventory ratios (especially finished goods). The revenue enhancing strategy requires buffered production systems. This is an example of

TABLE 3
*Regression results for the finished goods inventory ratio for the Belgian
wholesaling and retailing sector*

	Time	Output Growth
RETAIL	-0,0007***	-0,0056
WHOLESALE	-0,0004	-0,0170

* 0,1 level, ** 0,05 level, *** 0,01 level, **** 0,001 level

what we mentioned before: inventories do have a return as well. Therefore, the disappointing results obtained from our study do not necessarily mean that operations managers did a bad job. Avoiding the commodity trap also means that we will have to face more demand uncertainty, it becomes harder to forecast sales, etc. More uncertainty and more variability automatically means more buffers (see Lambrecht (2003)).

The strategy to focus on core competencies led many companies to increase the level of outsourcing. In Table 4 we show the degree of outsourcing for the 15 sectors studied. For every sector, we measure the ratio: *Amount Outsourced (materials+services) / Value of Shipments*. We observe a higher degree of outsourcing for all sectors except for chemicals. On average 75% of the value of shipments is outsourced. Contract manufacturing is becoming very popular in certain industries and more and more companies relocate their operations to low wage countries. This strategy inevitably results in loosening the just-in-time principles.

We are facing longer (and sometimes more variable) lead times, since products have to be shipped over long distances requiring more coordination in the supply chain. All this will result in additional

TABLE 4
Outsourcing in Belgian manufacturing sectors

	1980	1990	2000
TOTAL MANUFACTURING SECTOR (PU290)	69,59%	71,83%	75,41%
<i>non-energetic minerals & chemicals (PU2311)</i>	69,98%	68,75%	72,20%
iron & steel (PU2303)	69,64%	66,81%	74,47%
non-ferro metals (2304)	78,77%	79,13%	82,56%
non-metallic minerals (PU2302)	56,87%	63,68%	67,20%
chemicals (PU2312)	71,77%	68,80%	71,56%
<i>metal processing & optics (PU2511)</i>	62,98%	70,20%	73,19%
electronics & ICT (PU2611)	55,59%	66,81%	69,71%
<i>other manufacturing sectors (PU2850)</i>	74,18%	76,04%	78,11%
food & tobacco (PU270)	80,89%	80,80%	81,28%
textile (PU2801)	67,63%	70,17%	73,74%
apparel (PU2802)	68,38%	75,67%	80,43%
wood & furniture (PU2803)	64,23%	71,07%	74,52%
paper & printing (PU2811)	64,25%	67,81%	70,86%
rubber & plastics (PU2301)	66,81%	71,46%	77,09%

stocks. Add to that the strong export orientation of the Belgian economy. For a number of industries, higher exports mean less frequent deliveries and consequently higher finished product inventories.

V. CONCLUSION

Anecdotal evidence suggests that inventory ratios undoubtedly decreased in all sectors of the economy. Especially the manufacturing industry must be flagship of this efficiency improvement. This conjecture is not confirmed if we analyse the inventory holdings in greater detail. In this paper we report on an econometric study of the Belgian manufacturing sector. The results are encouraging but we get a mixed picture, since the inventory reductions are limited to a number of sectors, and the finished goods inventory ratio did overall not decrease. A similar conclusion was obtained by U.S. researchers.

What does that mean? Does it mean that operations managers did not manage their businesses properly? This conclusion would be far too brutal and totally unjust. The business strategy and the business model pursued by many companies include forces that potentially may increase inventory ratios. Increased product variety, commodity trap avoiding, outsourcing and contract manufacturing, profit enhancing strategies all have a potential to increase stocks. With roughly the same inventory holdings (and sometimes less) we do more and consequently the operations efforts contribute to the business model. This is the positive interpretation of our study. Of course we can still improve, we have to develop inventory management tools to better manage inventories in an international environment, with innovative products in uncertain and rapidly changing business conditions and develop performance measures that fit the business strategy.

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